Disturbances in the Ionosphere during the Geomagnetic Bay

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Disturbances in the Ionosphere during the Geomagnetic Bay

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§ 1. Introduction

It is well known that there occur some disturbances in the ionosphere during the geomagnetic perturbations, but the mechanism of the ionospheric disturbances is yet one of the unsolved problems of the ionosphere. As to the storm-time disturbances, the following facts have been cleared:

(a) The upward shift of the F2-layer,

(b) The remarkable decrase of the critical penetrating frequecy for the F2-layer,

(c) The abnormal increase of the ionic density in the E-region along the auroral zone.

These effects are, however, not so clear at the middle and low latitude, and particularly in the equatorial region, it is reported that the ionospheric effects are contrary to that at the high latitude [1]. Previously, the author studied the distribuion of the ionospheric disturbances during the geomagnetic storm on Apr. 18, 1951, using the hourly values of the ionospheric sounding at many stations widely distributed on the earth, and cleared that the values of $h'F2$ increased largely in the main phase of the magnetic storm and this upward shift was remarkable with the increase of the geomagnetic latitude, but the distribution of the deviation in the electron density was very complicated on account of the dependance on the magnetic time and the latitude [2]. As to the electron density, it is, therefore, a convinient way to consider two parts respectively corresponding to D_{st} or S_D.

There are some method to distinguish the disturbances corresponding to S_D from the storm-time variation, it is, however, a very simple method to treat with the disturbances during the geomagnetic bay which is one of the typical cases of the S_D-field. In this paper, the distribution of the deviation in $f^\circ F2$ during the magnetic bay is analysed with the object of clearing the storm-time disturbances in the ionosphere at the next steps.

§ 2. Data Used

It is desirable that the data of many stations as possible are used for this invetigation. Fortunately, comparatively abundant data obtained at the stations in the following list were provided by the Radio Wave Research Institute. These stations are marked on the map with numbers.

The magnetic bays were reported from the Kakioka Magnetic Observatory, and only the typical cases of them were selected by examining the magnetogram recorded at the Onagawa Magnetic Observatory. In the four equinoctial months of 1951 and in March, 1952, the sixty-five bays were selected for this investigation.

§ 3. The Deviation of the Electron Density in the F2-layer

The variation in $f^\circ F2$ were examined to see the deviations of the electron density in

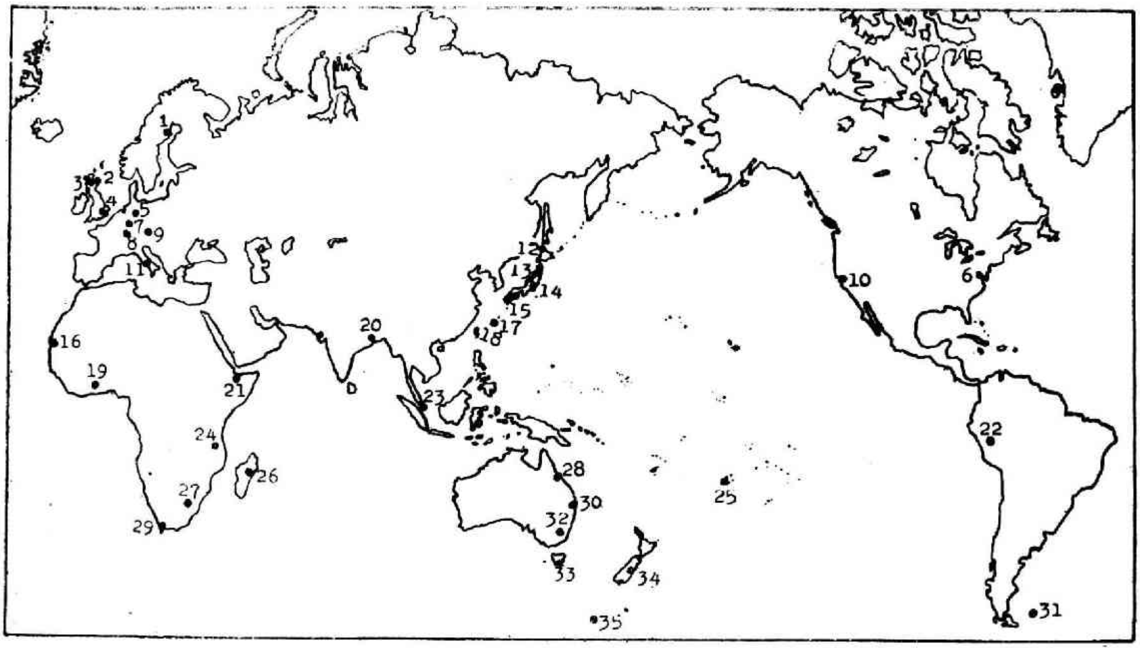

Fig. 1 The Distribution of the Ionospheric Stations

Table 1 Ionospheric Stations

No.	Station	Latitude	Longitude	Magnetic Lat.	No.	Station	Latitude	Longitude	Magnetic Lat.
1	KIRUNA	67.8°N	20.5°E	66°N	21	DJIBOUTI	11.5°N	43.1°E	7°N
2	FRASERBURGH	57.7°N	2.1°W	60 N	22	HUANCAYO	12.0°S	75.0 W	1°S
3	INVERNESS	57.5°N	4.3°W	60°N	23	SINGAPORE	1.4°N	103.8°E	9°S
4	SLOUGH	51.5°N	0.5°W	53°N	24	NAIROBI	10.0°S	37.0°E	13°S
5	LINDAU	51.7°N	10.1°E	51°N	25	RAROTONGA	21.3°S	159.8°W	21°S
6	WASHINGTON	38.7°N	77.1°W	51°N	26	TONANARIVE	13.8°S	47.8°E	24°S
7	FRIBOURG	48.1°N	7.8°E	49°N	27	JOHANNES-BURG	26.0°S	28.0°E	28°S
8	SCHWARZEN-BURG	46.8°N	7.3°E	47°N	28	TOWNSVILLE	19.3°S	146.8°E	30°S
9	GRAZ	47.1°N	15.5°E	47°N	29	CAPE TOWN	34.0°S	18.0°E	33°S
10	STANFORD	37.4°N	122.2°W	44°N	30	BRISBANE	27.5°S	153.0°E	40°S
11	ROMA	41.9°N	12.5°E	41°N	31	FALKLAND ISL.	51.7°S	57.9°W	42°S
12	WAKKANAI	45.4°N	141.7°E	35°N	32	CANBERRA	35.3°S	149.0°E	47°S
13	AKITA	39.7°N	140.1°E	30 N	33	HOBART	42.8°S	147.4°E	52°S
14	KOKUBUNJI	35.7°N	139.5°E	25°N	34	LINCOLN	43.6°S	172.7°E	54°S
15	YAMAGAWA	31.2°N	130.6°E	22°N	35	MACQUARIE ISL.	54.5°S	159.0 E	63°S
16	DAKAR	14.6°N	17.4°W	22°N					
17	OKINAWA	26.3°N	127.8°E	15°N					
18	TAIPEH	25.0°N	121.5°E	14°N					
19	IBADAN	7.4°N	4.0°E	11 N					
20	CALCUTTA	22.5°N	88.4°E	11°N					

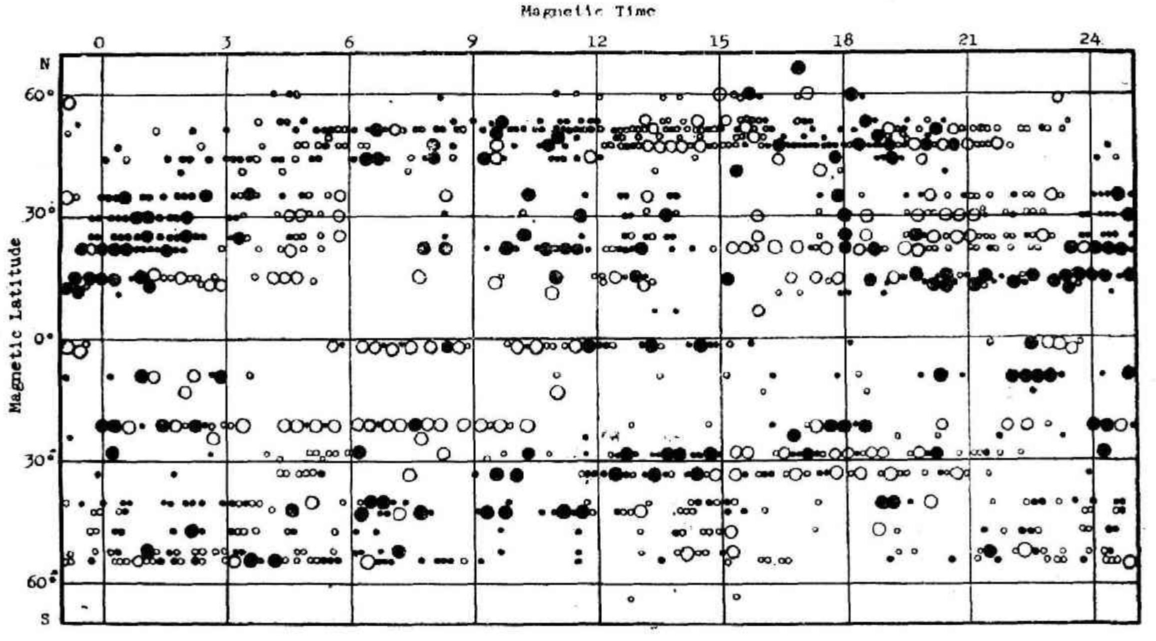

Fig. 2 Deviations in $f^{\circ}F2$

the F2-layer. In order to detect the deviations which were contained in the hourly observed values during the magnetic bays, it is neccessary to eliminate the diurnal variation in $f^{\circ}F2$. For this purpose, the differences between the observed values and the median values for the corresponding solar time were prepared. The mean value of the two of them immediately before the bay-disturbance was considered as the standard value, and the deviation in $f^{\circ}F2$ was detected by comparing the differences with this standard value. For each bay, the deviations were plotted in the figure according to the coordinates of the magnetic latitude and the magnetic time. Fig. 2 is made up by plotting the deviations accumlating for all the bays. In the figure, a small circle or dot corresponds to the increase or decrease of the range, 0.1—0.9 MC/S, respectively, and a large one indicates the deviation, positive or negative respectively, more than 1.0 MC/S. It is clear that the maximum electron density in the F2-region shows some systematic deviations according to the magnetic latitude and the time. Table II gives the mean values of the percentage deviations in the maximum electron density for each magnetic time at the various magnetic latitudes. On account of the small number of the bays, some stations at almost same latitude are considered together and the two-hourly running means are taken.

It is seen from Fig. 3 and Table II, that at the comparatively high latitude, the electron density increases in the afternoon, but near the sunset, there is a remarkable decrease which is similar to that pointed by APPLETON and PIGGOT [1], and MEEK [3] in the case of the geomagnetic storm. At the middle latitude, the semi-diurnal system of the deviations is noticable. At the low latitude near the magnetic equator, the negative deviations are experienced in the afternoon contrary to that at the high latitude.

There is surely a diurnal variaton of the deviations in the electron density during the geomagnetic bays, but some other periodic variatons are probably included.

Table II Mean Percentage Deviations in the Maximum Electron Density

Station	Fraserb. Inverne.	Slough	Washin. Lindau	Fribourg Schwarz. Graz	Stanford	Wakkanai	Akita	Kokubunji	Yamagawa Dakar	Okinaya Taipeh	Huancayo Singapo.	Rarotonga Tonanarive	Johanne. Townsvi. Cape to.	Brisbane Falkland	Canberra	Hobart Lincoln
Mean Mag. Lat.	+60°	+53°	+51°	+48°	+44°	+35°	+30°	+25°	+22°	+15°	-5°	-23°	-30°	-40°	-47°	-53°
Magnetic Time																
0	+26.4	+30.3	+28.6	-22.0	-1.7	+11.5	-17.7	-25.1	-45.0	-42.0	-3.5	-6.0	-42.3	-7.6	+1.4	+14.5
1	+27.9	+28.1	+42.8	-22.2	-26.4	-20.1	-16.2	-37.3	-25.9	-17.2	-6.2	-1.6	-47.0	-13.6	-11.0	+7.8
2	+11.1	+23.1	+9.4	+11.4	-29.6	-25.0	-2.2	-23.3	+4.5	+21.0	+10.7	-1.1	-39.8	-13.1	-21.2	+3.0
3	-27.8	+8.5	-16.3	+11.8	-11.1	-24.8	-6.4	-24.6	+35.5	+28.2	+16.6	+15.8	-53.9	-3.4	-15.5	+4.8
4	-27.8	-5.5	-13.7	+24.8	-10.9	-21.8	+14.0	-14.6	+41.2	+42.2	+25.1	+42.3	+14.5	+9.6	-6.5	+3.0
5	-25.7	-20.0	-18.2	+29.8	-14.7	+1.9	+47.1	+28.9	+30.4	+61.3	+4.4	+28.1	+18.9	+22.4	+23.6	+10.3
6	-19.8	-25.3	-29.0	+20.9	-33.0	+22.0	+38.8	+37.6	+14.3	+33.1	+21.2	+23.0	+2.2	-2.6	+1.8	-15.6
7	-29.3	-18.1	-19.5	+18.8	-6.3	+40.0	+8.6	+5.5	-27.4	+36.2	+21.5	+32.1	+15.6	-21.2	-26.0	-35.2
8	-26.2	-15.7	-12.1	-31.4	+1.9	+53.2	-12.9	-14.9	-39.7	+30.9	+8.2	+32.4	+51.1	-13.7	-12.9	-25.6
9	-24.5	-14.1	-15.2	-13.7	-12.8	+49.2	-20.5	-14.5	-38.0	+19.5	+2.6	+26.7	+29.4	-32.3	-6.0	-12.5
10	-16.5	-13.3	-15.2	-6.9	-15.4	-22.6	-11.6	-51.0	-9.5	+17.1	+9.7	+25.2	-9.2	-19.6	-5.7	-9.4
11	-3.7	-13.0	-9.3	-16.1	-17.4	-16.8	-10.8	-28.6	-19.0	-20.3	+5.7	+12.6	-11.9	-12.3	-16.4	-14.9
12	+3.2	-6.9	+3.4	-3.0	-10.0	-14.0	-21.6	-6.5	-21.6	-4.6	+5.7	+3.9	-8.1	-4.3	-5.4	-14.5
13	+7.2	+1.8	+10.9	+16.3	-5.1	-7.0	-10.4	-4.1	-8.7	+3.8	+4.6	+10.6	-12.4	+8.1	+10.6	+12.5
14	+10.7	+9.7	+15.2	+17.1	+7.7	+2.5	-2.8	-5.2	-3.8	-1.2	-10.8	+9.6	-12.0	+7.8	+5.4	+15.9
15	+14.8	+12.9	+16.6	+10.4	+8.0	+2.6	+26.1	+65.4	+17.8	-32.8	-4.9	+9.6	-16.1	-0.8	+10.4	+15.2
16	+16.4	+8.3	+12.2	+1.4	+32.2	-10.7	+27.5	+68.4	+36.3	-9.3	-5.5	-15.7	-11.6	+5.3	+21.0	+7.0
17	+8.0	-3.3	-4.1	-9.4	+2.9	-23.7	+2.6	+12.4	+23.3	+19.2	-12.3	-9.5	+4.6	+19.3	+2.9	+1.5
18	-17.1	-16.8	-4.2	-14.2	-19.9	-7.0	-2.3	+2.7	+1.1	-17.0	-7.7	-13.1	+10.1	-17.6	+3.0	0
19	-37.7	-22.0	+10.6	-4.0	0	-6.6	+2.6	-1.6	+14.5	-36.9	-8.8	-5.8	+17.6	-50.5	+24.8	+4.1
20	-39.0	-19.2	+18.0	0	+10.9	-10.3	+21.8	+13.3	+29.1	-11.7	-21.6	+20.4	+23.9	+15.6	+27.6	-6.6
21	-14.5	-6.8	+17.0	+9.7	+12.6	+1.5	+9.4	+18.0	+12.0	-19.6	-11.4	+17.1	+20.3	+41.2	-12.4	-11.7
22	+21.8	+16.1	+16.8	+25.9	+8.0	+6.8	0	+16.2	+10.8	-13.4	-12.3	+13.9	+14.1	+3.2	-9.4	+3.0
23	+23.3	+29.4	+17.3	+20.7	0	+21.0	+3.3	+6.4	-22.0	-29.9	-12.3	+6.7	-2.6	-2.4	+6.3	+9.6

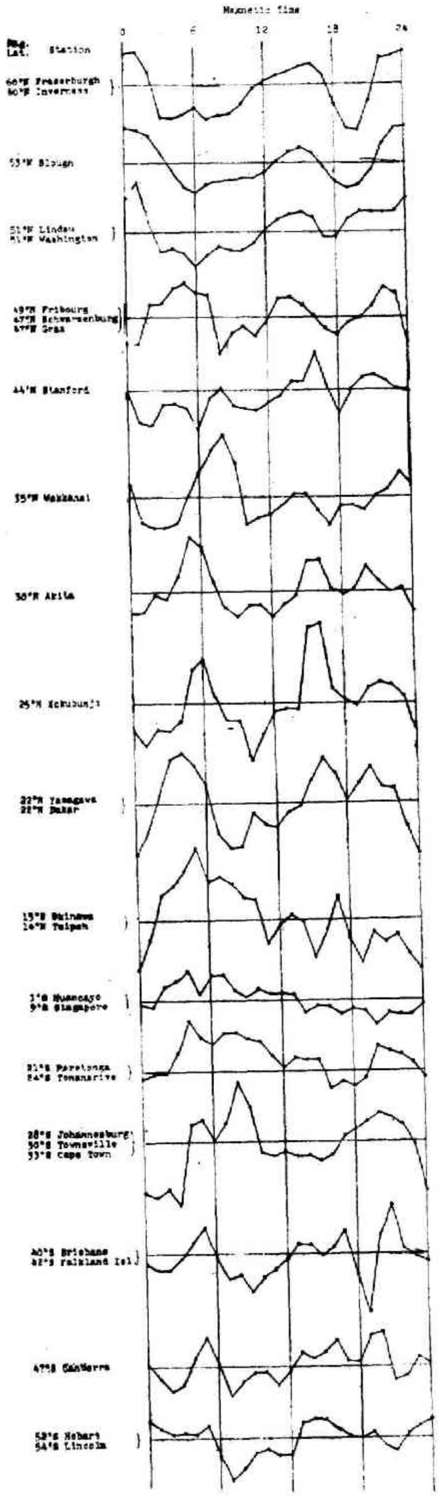

Fig. 3 The percentage deviations in the maximum electron density at the various stations.

§ 4. The Harmonic Analysis of the Deviations

The result of the harmonic analysis of the percentage deviations in the maximum electron density in the F2-region is given in Table III. It is seen from the table that P_2's are comparatively large at the high latiude and P_2/P_1 is, in general, larger at the high latitude than at the low latitude. It is an interesting character that A_1 and A_2 show some systematic variation according to the geomagnetic latitude. These variations in the phases suggest some connections with the tidal effect in the ionosphere deduced by MARTYN [4].

Using the coefficients in the table, the percentage deviations are illustrated in Fig. 6 for the various latitudes. Fig. 6 (a) corresponds to the first harmonics, and Fig. 6 (c) shows

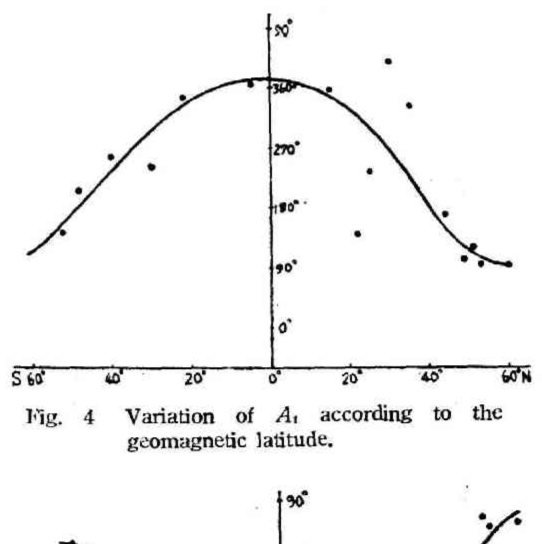

Fig. 4 Variation of A_1 according to the geomagnetic latitude.

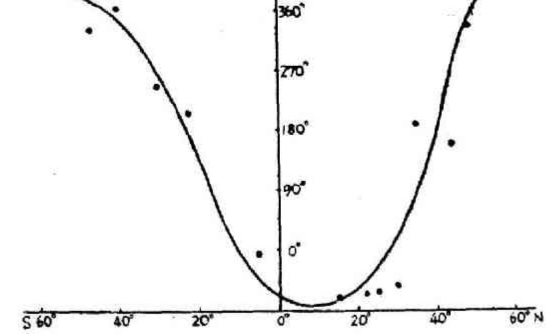

Fig. 5 Variation of A_2 according to the geomagnetic latitude.

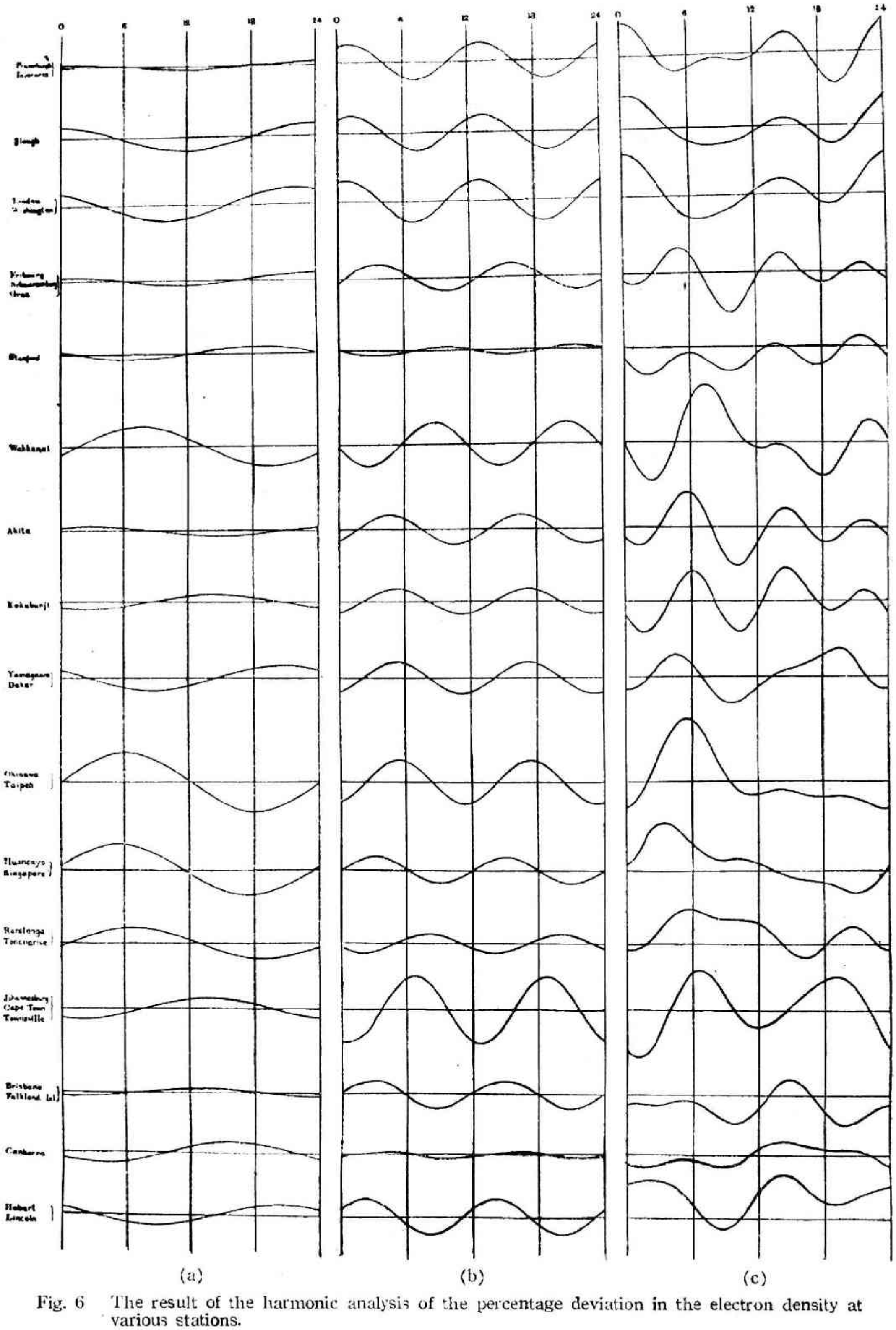

Fig. 6 The result of the harmonic analysis of the percentage deviation in the electron density at various stations.

Table III The Harmonic Coefficients

Station	a_0	P_1	A_1	P_2	A_2	P_3	A_3	P_2/P_1
FRASERBURGH, INVERNESS	− 0.3	3.3	95°	17.7	56°	14.1	99°	5.54
SLOUGH	0	12.0	94°	16.4	50°	5.7	96°	1.37
WASHINGTON, LINDAU	+ 4.1	15.6	121°	20.0	63°	5.7	97°	1.28
FRISOURG, SCHWARZENBURG, GRAZ	− 2.3	5.6	105°	12.7	337°	16.8	200°	2.27
STANFORD	− 9.8	6.3	170°	3.4	159°	11.8	192°	0.54
WAKKANAI	+ 1.1	19.0	336°	20.9	188°	21.0	148°	1.10
AKITA	− 0.8	4.7	46°	14.1	310°	19.7	182°	3.62
KOKUBUNJI	− 0.1	7.1	233°	11.9	295°	21.9	171°	1.56
YAMAGAWA, DAKAR	+ 3.6	11.6	141°	14.9	295°	9.4	243°	1.22
OKINAWA, TAIPEH	+ 1.5	28.0	358°	20.7	289°	9.3	213°	0.71
HUANCAYO, SINGAPORE	+ 6.7	23.6	8°	12.3	358°	6.3	324°	0.52
RAROTONGA, TONANARIVE	+ 11.0	14.4	340°	8.8	208°	9.1	251°	0.61
JOHANNESBURG, TOWNSVILLE, CAPE TOWN	+ 2.9	10.0	244°	31.6	247°	7.9	189°	3.16
BRISBANE, FALKLAND ISL.	− 10.0	3.9	253°	13.2	5°	8.3	146°	3.39
CANBERRA	− 1.0	10.3	209°	2.7	331°	4.5	217°	0.26
HOBART, LINCOLN	+ 1.4	9.9	143°	16.9	27°	6.1	214°	1.71

the compositions up to the third term. Fig. 6(b) illustrates only the second harmonics.

The distribution of the deviation in $h'F2$ or h_pF2 will be studied in later paper. The combination of the investigations on $f^\circ F2$ and h_pF2 will give a light on the problem of the ionospheric disturbances corresponding to the S_D-field.

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References

[1] E. V. APPLETON and W. R. PIGGOTT; *J. Atmos. Terr. Phys.* 2, 236 (1952)

[2] H. KAMIYAMA; *Rep. Ionosph. Res. in Japan* 6, 47 (1952)

[3] J. H. MEEK; *J. Geophys. Res.* 57, 177 (1952)

[4] D. F. MARTYN; *Proc. Roy. Soc.* A 189, 241 (1947)